HEMEROCALLIS HAKUUNENSIS (LILIACEAE) IN KOREA

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ABSTRACT

Principal components analysis shows that the type of *Hemerocallis micrantha* Nakai is included in the continuous range of morphological variation of populations of *H. hakuunensis* Nakai (southern, central, and northwestern Korea). *Hemerocallis hakuunensis* has priority and is the correct name for this taxon. Also, the result shows that *H. middendorffii* (central and northeastern Korea) is distinct from *H. hakuunensis* by having a capitate-type inflorescence, large inflorescence bracts, short perianth tube and a different flowering period. Synonymy, descriptions, and distribution pattern of *H. hakuunensis* are included.

RESUMEN

El análisis de componentes principales muestra que el tipo de *Hemerocallis micrantha* Nakai está incluido en el rango continuo de variación morfológica de las poblaciones de *H. hakuunenis* Nakai (sur, central y noroeste de Korea). *Hemerocallis hakuunensis* tiene prioridad y es el nombre correcto para este taxon. Los resultados muestran también que *H. middendorffii* (centro y noreste de Korea) se diferencia de *H. hakuunensis* por tener inflorescencias de tipo capitado, brácteas de la inflorescencia grandes, tubo del perianto corto y un periodo de floración diferente. Se incluyen sinonimias, descripciones y patrones de distribución de *H. hakuuensis*.

INTRODUCTION

Hemerocallis L. is an economically important genus of approximately 30 species restricted to mainly eastern Asia (Matsuoka and Hotta 1966). Many species and cultivars are widely grown in gardens in Asia, Europe, and North America (Cohen 1986). Numerous nomenclatural and taxonomic problems exist within the genus (Matsuoka and Hotta 1966; J. Noguchi pers. comm.). The taxonomic difficulty has been attributed to the relative paucity of diagnostic characters, the fact that many species (e.g., *H. aurantiaca* Baker, *H. flava* L., *H. fulva* L., and *H. thunbergii* Baker) were described from cultivated plants of unknown origin (Kitamura et al. 1986; Matsuoka and Hotta 1966), the extreme difference in appearance between living plants and dried herbarium specimens, and possible widespread hybridization (Kitamura et al. 1986). In addition, many species of *Hemerocallis* are so variable ecologically and morphologically that a proper species concept requires morphological, ecological and biosystematic studies. Over 27,000 cultivars further confound the taxonomic status of several *Hemerocallis*

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species. Matsuoka and Hotta (1966) noted that Baily (1930), Nakai (1932), and Stout (1941) did not consider the variability of natural populations when developing their classification. Based on the taxonomic literature on the genus *Hemerocallis* (e.g., Nakai 1932; Matsuoka and Hotta 1966; Hotta 1986; Kitamura et al. 1986), the geographical and ecological distribution of the Japanese *Hemerocallis* is relatively well known. On the other hand, little is known of the Korean *Hemerocallis*. After Nakai's (1932) description of *H. coreana* Nakai as the endemic *Hemerocallis* species in Korea, he (Nakai 1943) described two other taxa; *H. hakuunensis* Nakai and *H. micrantha* Nakai. Matsuoka and Hotta (1966) recognized *H. fulva* var. *minor* (Miller) M. Hotta, *H. flava* var. *coreana* (Nakai) M. Hotta, *H. dumortieri* Morren var. *middendorffii* (Tr. et Mey.) Kitamura, and *H. hakuunensis* as the indigenous species in Korea. Lee (1985) reported 6 species and two cultivated plants from Korea: *H. fulva* L. (cultivated plant), *H. fulva* var. *kawanso* Regel (cultivated plant), *H. flava*, *H. littorea* Makino, *H. dumortieri*, *H. middendorffii*, *H. minor* and *H. thunbergii*. The recognition of Korean *Hemerocallis* species has varied depending on authors. Consequently, there is an obvious need to study the group in detail to understand better the taxonomy of *Hemerocallis*. Principal components analysis of morphological data has been widely used to study species delimitation; e.g., Noguchi (1986) for the *Hemerocallis dumortieri* complex and Chung et al. (1991) for the Korean *Hosta* (Liliaceae).

The goals of this study were to 1) analyze morphological variation between *H. hakuunensis* and *H. middendorffii;* 2) determine the overall geographic distribution patterns for *H. hakuunensis* and *H. middendorffii*; and 3) more closely conform the descriptions to the typical morphology of *H. hakuunensis*. More specifically, do the two species *H. hakuunensis* and *H. micrantha* merit taxonomic distinction at the rank of species?

MATERIALS AND METHODS

Several morphological characters were measured for five individuals from 16 populations in Korea from 1988 to 1993 (Fig. 1; Table 1). Observations were also made of the habitats, and notes were taken on characteristics (e.g., soil types) of the populations. Voucher specimens of all collections are deposited at GNUC. In addition, five herbarium specimens of *H. middendorffii* and the two types of *H. hakuunensis* and *H. micrantha* (Table 1) were used to determine if 1) the types of the latter two names fall within one continuous field of variation and 2) *H. hakuunensis* and *H. micrantha* are morphologically distinct by comparison with *H. middendorffii*. The herbaria of Seoul National University (SNU) and Tokyo University (TI) were visited in order to search type specimens of *H. hakuunensis* and *H. micrantha* and determine the total range of geographic variation and the distribution of North Korean *Hemerocallis* (Fig. 1).

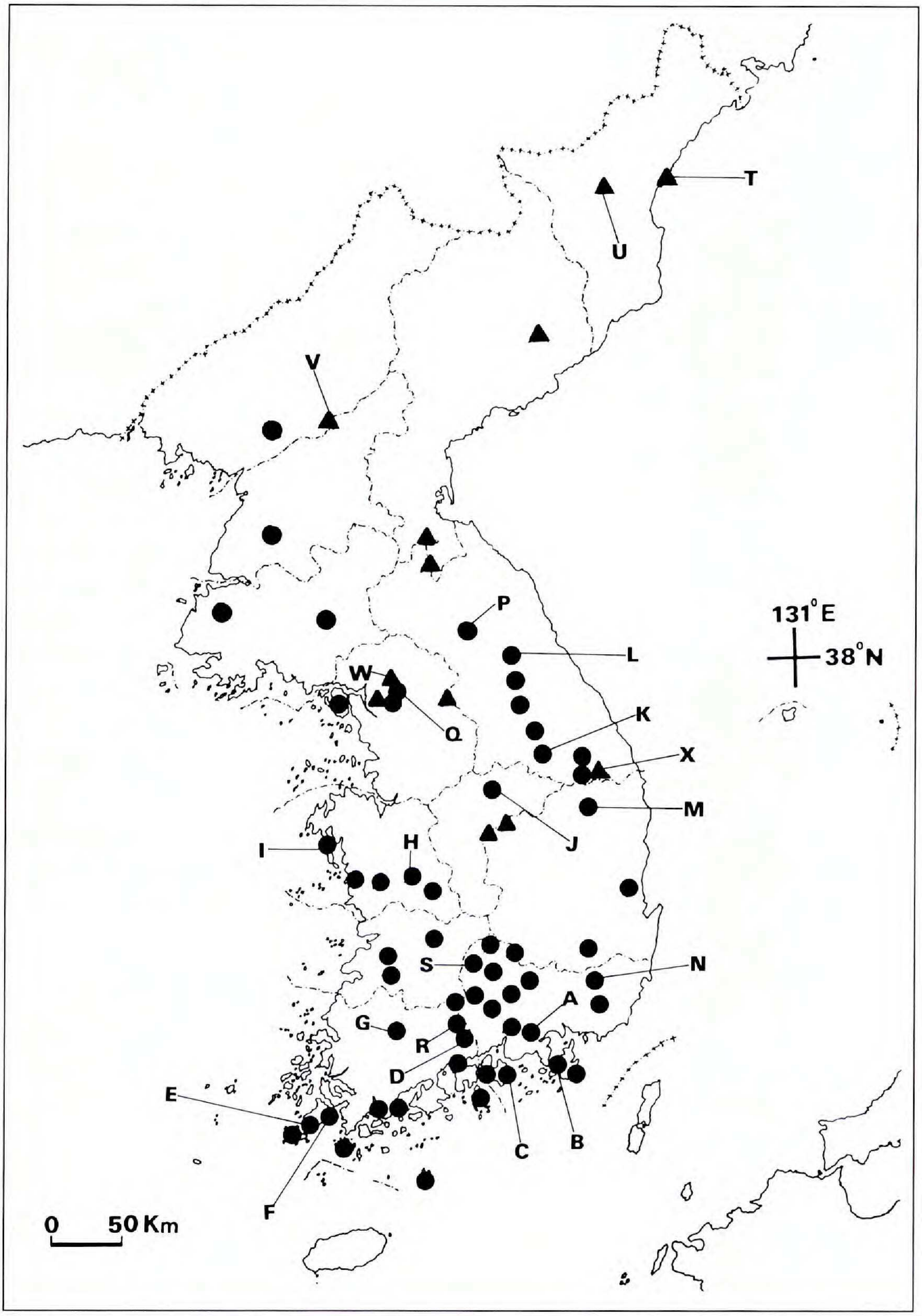


FIG. 1. Geographical distribution of *Hemerocallis hakuunensis* and *H. middendorffii* in Korea. Arrows with alphabetic codes (A-N, P and Q) indicate locations of populations from which samples were collected by M. G. Chung and S. S. Kang. Arrows with codes (R-X) indicate locations from which herbarium specimens were collected. See Table 1 for the explanation of 23 alphabetic codes.

TABLE 1. Locations of 16 populations and seven herbarium specimens examined for morphological phenetic analysis. All collections by M. G. Chung and S. S. Kang except others noted.

Code	Locations	Collection number
1)	*Hemerocallis hakuunensis*, southern, central and northwestern Korea	
A	Bongam-ri, Chincheon-myeon, Uich'ang-gun, Gyeongsangnam-do	1850
B	Sorang-ri, Koje-myeon, Koje-gun, Koje Island, Gyeongsangnam-do	1851
C	Mizo-myeon, Namhae-gun, Namhae Island, Gyeongsangnam-do	1852
D	Masa-ri, Bonggang myeon, Kwangyang-gun, Chollanamdo	1853
E	Pyeongmok-ri, Imwhe-myeon, Chindo-gun, Chin Island, Chollanam-do	1863
F	Ch'osang-ri, Uishin-myeon, Chindo-gun, Chin Island, Chollanam-do	1864
G	Gurea-ri, Leeyang-myeon, Whasun-gun, Chollanam-do	1866
H	Yongdam-ri, Kumnam-myeon, Yeongi-gun, Ch'ungch'ongnam-do	1871
I	Changgi-ri, Anmyeon-eup, Seosan-gun, Ch'ungch'ongnam-do	1874
J	Hwayangdong Provincial Park, Ch'ungch'ongbuk-do	1875
K	Danyang-gun, Sobaksan National Park, Ch'ungch'ongbuk-do	1878
L	Yuljeon-ri, Dae-myeon, Hongch'on-gun, Kangwon-do	1881
M	Angi-ri, Bookhu-myeon, Andong-gun, Gyeongangbuk-do	1884
N	Sangbuk-myeon, Uljoo-gun, Gagisan Provincial Park, Gyrongsangnam-do	1887
P	Komnam-myeon, Ch'olwon-gun, Kangwon-do	2001
Q	Kwangnung, Sohul-myeon, Poch'on-gun, Gyeonggi-do	2002
R	Holotype, Mt. Baekun, Chollanam-do	*Nakai s.n.* (TI)
2)	*Hemerocallis micrantha*, Hamyang-gun, Gyeongsangnam-do	
S	Holotype, Hamyang-gun, Gyeongsangnam-do	*O. Syogo s.n.*(TI)
3)	*Hemerocallis middendorffii*, central and northeastern Korea, Manchuria, Amur	
T	Ch'ungjin-shi, Hamgyeongbuk-do	*Nakai s.n.* (TI)
U	Mt. Kwanmyobong, Gyeongsung-gun, Hamgyeongbuk-do	*Toh 4507* (SNU)
V	Mt. Myohwang, Hwich'un-gun, P'yeonganbuk-do	*Toh & Shim 12784* (SNU)
W	Kwangnung, Poch'un-gun, Gyeonggi-do	*Toh 900* (SNU)
X	Mt. Myeon, Taebaek-shi, Kangwon-do	*Oh s.n.* (SNU

Previous studies (Matsuoka and Hotta 1966; Hotta et al. 1966; Hotta 1986; and Noguchi 1986) revealed that several qualitative (e.g., flowering time and period, shape of roots, odor, and type of an inflorescence) and quantitative characters (e.g., floral and leaf morphologies and wintering conditions of leaves) are important characters in recognizing *Hemerocallis* taxa. As most qualitative characters were not available from the herbarium specimens, only 14 morphological characters were selected in this study (Table 2).

Phenetic analyses were utilized to assess the morphological variation present in 87 OTUs (operational taxonomic units) of *H. hakuunensis*, *H. micrantha*, and *H. middendorffii*. Principal components analyses (PCAs) were performed to identify characters contributing to the separation of each taxon and assess inter-taxon variation using the Statistical Analysis System (SAS 1987). The data were standardized for each character, with the raw data matrix transformed such that each character had a mean of zero as a standard deviation (Sneath and Sokal 1973). The first three principal components were extracted by the PCAs.

TABLE 2. List of 14 characters used in the morphological analysis.

Acronym	Character derivation	Unit or Category
PSH	Plant (scape) height	> 50cm=0; < 50cm=1
LSI	Length of inflorescence minus flowers	> 1cm=0; 2-20cm=1
NFS	Number of flowers/scape	#
LLB	Length of the lowest bracts	cm
WLB	Width of the lowest bracts	cm
LPO	Length of the perianth tube enclosing ovary	cm
LIP	Length of the inner perianth	cm
WIP	Width of the inner perianth	cm
LOP	Length of the outer perianth	cm
WOP	Width of the outer perianth	cm
WWL	Width of the widest leaves	cm
ROL	Ratio of inner to outer lobe length	ratio
ROW	Ratio of inner to outer lobe width	ratio
SOI	Shape of inflorescence	head or cap type=0; Y-type or branched=1

RESULTS

The cumulative variance of the first three principal components (64.8%) and the contributing value of each of 14 characters are shown in Table 3. Characters weighted heavily in the first principal component (27.4%) are width of the outer perianth (WOP), width of the inner perianth (WIP), shape of inflorescence (SOI), and plant height (PSH). The second component accounts for 25.0% of the total variation and is mostly concerned with length of the perianth tube enclosing the ovary (LPO), SOI, PSH, length of inflorescence minus flowers (LSI), length of the outer perianth (LOP) and length of inner perianth (LIP). The third component accounts for 12.4% of the total variation and number of flower per scape (NFS), length of the lowest bracts (LLB), and width of the widest leaves (WWL) are highly weighted.

Results from two-dimensional plots of component 2 against components 1 and 3 (Figs. 2 and 3) show that the type specimen of *H. micrantha* is marginally included in the continuous range of variation described by the OTUs of *H. hakuunensis* (populations A-N, P and Q) including the type (R). The range of variation for *H. hakuunensis* is distinct from that of *H. middendorffii*.

TAXONOMIC DISCUSSION

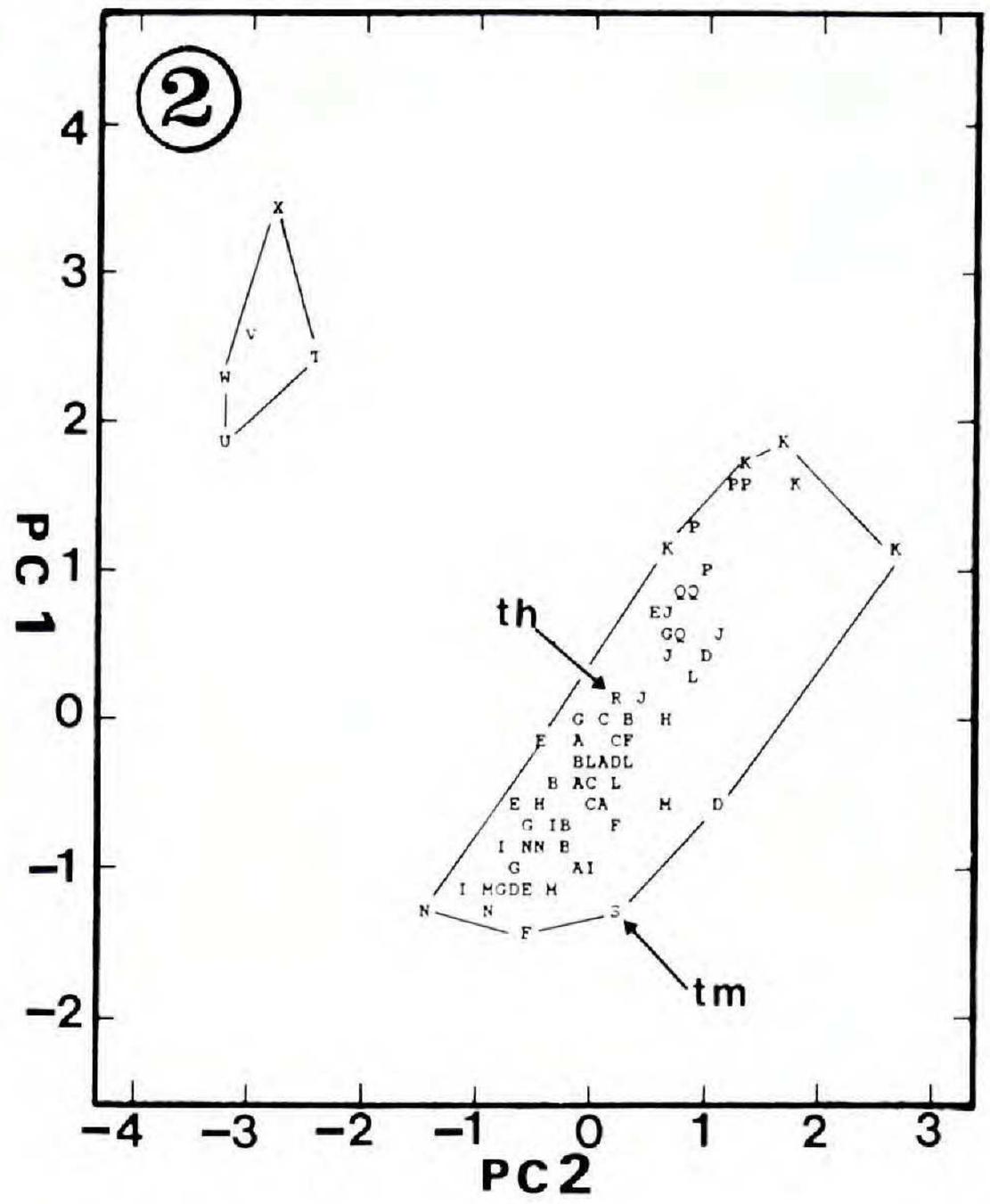
Hemerocallis middendorffii, found on open areas of central and northeastern mountains in Korea (S.S. Kang pers. obs.; S.H. Oh pers. comm.), differs from *H. hakuunensis* by having a capitate-type inflorescence; large inflorescence bracts (2.0–4.0 cm long, 1.0–3.0 cm wide); short perianth tube (1.0–1.8 cm long); short scape (30–47 cm long); and a different flowering period from middle May to June. The results from principal components analysis revealed these two species are distinct from each other (Figs. 2–3).

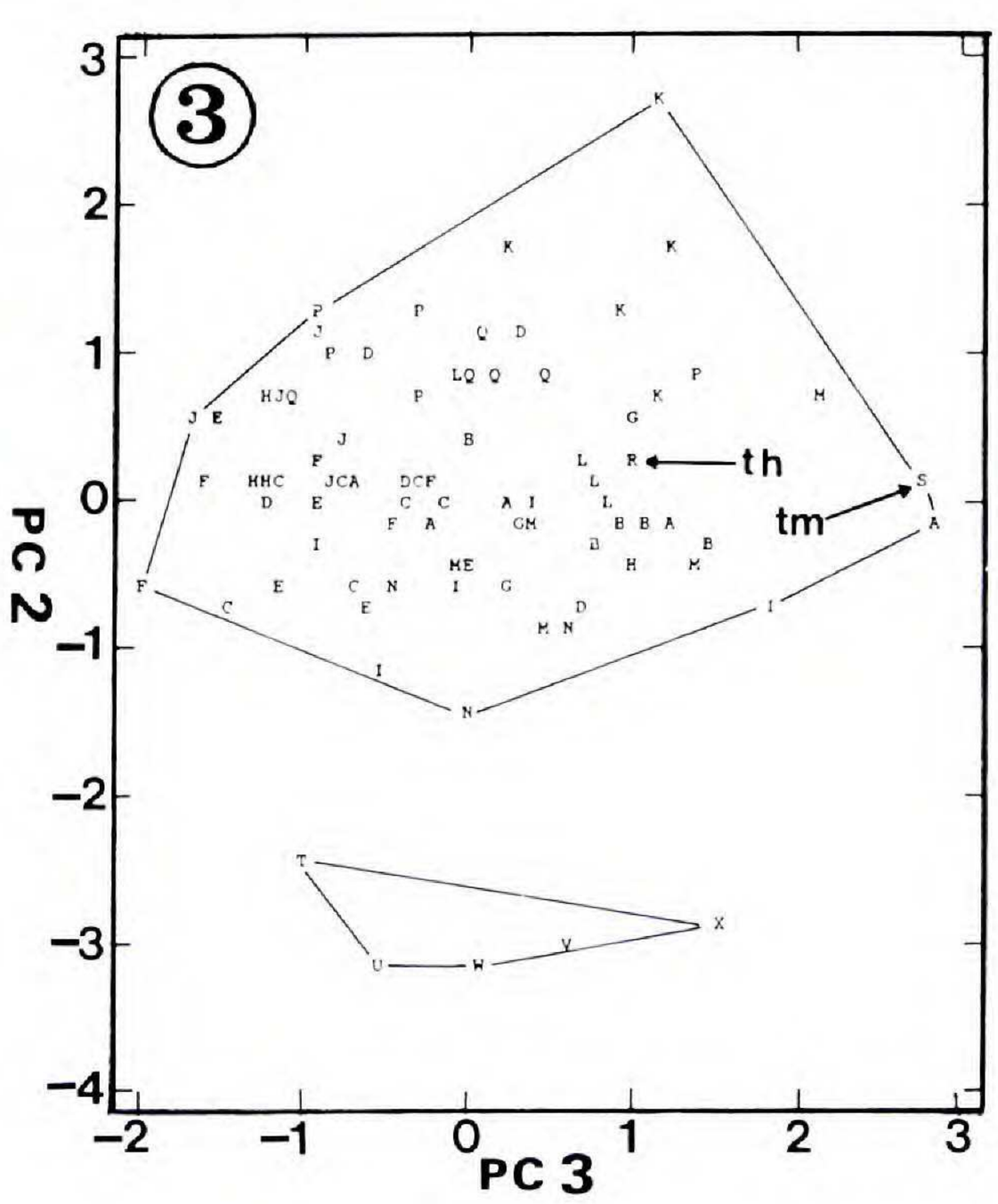
TABLE 3. First three principal components composed of 87 OTUs derived from 14 morphological characters.

Acronym[a]	PC 1	PC 2	PC 3
PSH	-0.625	0.724	-0.034
LSI	-0.503	0.694	0.207
NFS	-0.434	0.098	0.608
LLB	0.048	0.140	0.580
WLB	0.602	-0.194	0.502
LPO	-0.075	0.722	-0.072
LIP	0.574	0.657	-0.317
WIP	0.790	0.271	-0.115
LOP	0.569	0.668	-0.308
WOP	0.828	0.313	0.159
WWL	0.231	0.445	0.572
ROL	-0.131	-0.301	0.082
ROW	-0.453	-0.196	-0.406
SOI	-0.625	0.724	-0.034
Eigenvalue	3.830	3.496	1.742
Proportion of variance	27.4%	25.0%	12.4%
Cumulative variance	27.4%	52.4%	64.8%

[a]See Table 2 for character explanation.

Nakai (1943) originally described *H. micrantha* based on only one herbarium specimen collected by O. Syogo from Hamyang, Prov. Gyeongsang Nam of southern Korea. He noted that *H. micrantha* is distinct from other species by having small-sized orange-yellow flowers and a highly branched inflorescence. For example, he reported that the length and width of perianth lobes are 4 cm and 5–6 mm, respectively, and the length of inflorescence is 23 cm long. These values are included in the continuous range of variation observed during our field trips for *H. hakuunensis*. Individuals with 20–30 cm long inflorescences were encountered within the populations of D, K, and M. Individuals with small-sized (ca. 4–6 cm long) length of perianth lobes were also observed within the populations of A, B, D, E, I, M, and N. In addition, the flowering date (17 July) and collection location (Prov. Gyeongsang Nam of southern Korea) for *H. micrantha* fall within the range of flowering period (June to July, August in the mountainous areas) and geographic distribution (southern, central, and northwestern Korea) of *H. hakuunensis*. It is highly probable that the type of *H. micrantha* is one of the variable individuals observed for *H. hakuunensis* as revealed by PCAs (Figs. 2–3). Although *H. hakuunensis* and *H. micrantha* were published in 1943 on the same volume of *Journal of Japanese Botany* (pp. 315–316), *H. hakuunensis* has priority over *H. micrantha* because the former was described ahead of the latter. So *H. hakuunensis* is the correct name for the taxon.





FIGS. 2-3. Diagrams showing the results of PCAs. **th** and **tm** = holotype of *Hemerocallis hakuunensis* and *H. micrantha*. FIG. 2. PCA (components 1 and 2) composed of 87 OTUs. FIG. 3. PCA (components 2 and 3) composed of 87 OTUs.

Matsuoka and Hotta (1966, p. 37) also considered *H. micrantha* as a synonymy of *H. hakuunensis*. The nomenclature is as follows:

Hemerocallis hakuunensis Nakai, J. Jap. Bot. 19:315. 1943. TYPE: KOREA. PROV. CHOLLA NAM: Mt. Baekun, 22 Aug 1934, *Nakai s.n.* (HOLOTYPE: TI!; ISOTYPE: TI!). PARATYPE: **KOREA.** PROV. CHOLLA NAM: Mt. Chiri, 25 Jul 1937, *O. Syogo s.n.* (TI!).

Hemerocallis micrantha Nakai, J. Jap. Bot. 19:315–316. 1943. TYPE: KOREA. PROV. GYEONGSANG NAM: Hamyang, 17 Jul 1937, *O. Syogo s.n.* (HOLOTYPE: TI!).

Herbaceous perennials. Roots usually tuberous (ca. 1.5–2.0 cm long, 0.8 cm wide), grayish yellow. Leaves 40–100 cm long, 1.2–2.5 cm wide, greenish yellow. Scapes ascendant or erect, 32–145 (80 ± 15.62, mean ± SD) cm long, nearly as long as or shorter than leaves, usually 1–2 lanceolate bracts below the inflorescence, 1.2–6.0 (9.5) cm long, 0.7–1.8 cm wide; inflorescence branched (rarely Y-type) with 4–27-flowers, 3–30 (10.82 ± 4.43) cm long; bracts ovate, greenish, membranous on margin. Perianth (fresh) orange-yellow, 7–10 cm long, tube 1.5–3.0 cm long, green with orange tint; throat orange yellow; inner perianth lobes 4.5–9.0 cm long, 1.6–2.6 cm wide. Stamens 3–4 cm long, inserted; filaments orange-yellow, attached to the base of the perianth tube; anthers ca. 6 mm long, dark brown with purple tint. Style filiform, ca. 8.5 cm long, exerted beyond the stamens. Capsule usually oblong-oval, 2.0–2.5 cm long and 1.1–1.5 cm wide, cross-wrinkled when dried, surface usually covered with wart-like projections, apex emarginate; seeds shining black, angled, 6 mm long, 4 mm wide. Flowering from June to July (August in the mountainous areas) in Korea; fruit ripening late July to September.

Korean name: Baekunsan-wonch'uri

This species is commonly found on the humus or granitic soils and open areas or under pine-oak forests on hillsides of southern, central, and northwestern Korea, including Kojae, Namhae, Komun, Dolsan, Pogil, Chin, Anmyeon, and Kangwha islands (Korean endemic species).

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